DECLARATION

I, the below-named translator, hereby declare:

(1) That my name, mailing address and citizenship are as stated below;

(2) That I am knowledgeable in the English language and in the Japanese language in which Japan Patent Application No. 2001-043460 was filed on February 20, 2001; and

(3) That I have translated said Japan Patent Application No. 2001-043460 into English, whose English text is attached hereto, and believe that said translation is a true and complete translation of the aforementioned Japan patent application.

July 15, 2005

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JAPAN PATENT OFFICE

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- Abstract 1

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[TITLE OF INVENTION]

ELECTRON TUBE AND METHOD FOR PRODUCING SAME

[CLAIMS]

1. An electron tube comprising:
at least one metal layer formed on a base;
at least one metal piece disposed on said at least one metal layer;
at least one linear member interposed between said at least one metal layer and said at least one metal piece,
wherein said at least one linear member is fixedly attached to said at least one metal layer by welding said at least one metal piece to said at least one metal layer.

2. An electron tube comprising:
at least one cathode electrode formed on a base;
at least one metal piece disposed on said at least one cathode electrode;
at least one cathode linear member interposed between said at least one cathode electrode and said at least one metal piece,
wherein said at least one cathode linear member is fixedly attached to said at least one cathode electrode by welding said at least one metal piece to said at least one cathode electrode.

3. An electron tube comprising:

at least one grid electrode formed on a base;

at least one metal piece disposed on said at least one grid electrode;

at least one grid linear member interposed between said at least one grid electrode and said at least one metal piece,

wherein said at least one grid linear member is fixedly attached to said at least one grid electrode by welding said at least one metal piece to said at least one grid electrode.

4. An electron tube comprising:

at least one metal layer formed on a base;

at least one metal piece disposed on said at least one metal layer;

at least one cathode supporting auxiliary linear member or at least one grid supporting auxiliary linear member interposed between said at least one metal layer and said at least one metal piece,

wherein said at least one cathode supporting auxiliary linear member or said at least one grid supporting auxiliary linear member is fixedly attached to said at least one metal layer by welding said at least one metal piece to said at least one metal layer.

5. An electron tube of any one of claims 1 to 4, wherein the welding is achieved by using an ultrasonic bonding.

6. An electron tube of any one of claims 1 to 5, wherein said at least one metal piece is independently provided to said at least one linear member.

7. An electron tube of any one of claims 1 to 5, wherein said at least one linear member is divided into a plurality of sets and said at least one metal layer is at least one pair of metal layers, each of the sets being provided with one pair of said at least one pair of metal layers.

8. A method for producing an electron tube comprising the steps of:

interposing at least one linear member between at least one metal layer formed on a base and at least one metal piece disposed on said at least one metal layer; and

fixing said at least one linear member to said at least one metal layer by ultrasonic-bonding said at least one metal piece to said at least one metal layer.

9. A method for producing an electron tube comprising the steps of:

interposing at least one cathode linear member between at least one cathode electrode formed on a base and at least one metal piece disposed on said at least one cathode electrode; and

fixing said at least one cathode linear member to said at

least one cathode electrode by ultrasonic-bonding said at least one metal piece to said at least one cathode electrode.

10. A method for producing an electron tube comprising the steps of:

interposing at least one grid linear member between at least one grid electrode formed on a base and at least one metal piece disposed on said at least one grid electrode; and

fixing said at least one grid linear member to said at least one grid electrode by ultrasonic-bonding said at least one metal piece to said at least one grid electrode.

11. A method for producing an electron tube comprising the steps of:

interposing at least one cathode supporting auxiliary linear member or at least one grid supporting auxiliary linear member between at least one metal layer formed on a base and at least one metal piece disposed on said at least one metal layer; and

fixing said at least one cathode supporting auxiliary linear member or said at least one grid supporting auxiliary linear member to said at least one metal layer by ultrasonic-bonding said at least one metal piece to said at least one metal layer.

[DETAILED DESCRIPTION OF THE INVENTION]

[FIELD OF THE INVENTION]

The present invention relates to an electron tube equipped with a linear member such as a linear filament, linear spacers, a linear damper or a wire grid, and a producing method thereof.

[DESCRIPTION OF THE PRIOR ART]

Referring to Figs. 9, 10 and 11, embodiments of the conventional electron tube, for example, the conventional display device will be described.

There are shown in Fig. 9(a) and 9(b) a partial top view of a first prior art fluorescent display device and a cross sectional view taken along a line X1-X1 of Fig. 9(a), respectively.

As shown, the first prior art display device includes a glass substrate 51, a pair of metallic plates 52, 53 formed on the glass substrate 51, an anchor 54 and a support 55 which are respectively installed at the metallic plates 52, 53 via a pair of mounting portions 541, 551 thereof, and a cathode filament 56. Referring to Fig. 9(b), one end of the filament 56 is fixed to the anchor 54 and the other end thereof is fixed to the support 55. In this case, the anchor 54 acts as a resilient member for exerting the tension force on the filament 56 so that it will not hang down and the support 55 functions as a post for supporting the filament 56.

Fig. 10(a) illustrates a top view of a prior art display device in case two cathode-filament-mounting parts are located in parallel, and Fig. 10(b) illustrates a cross sectional view taken along a line X2-X2 of Fig. 10(a). When a driving system for applying DC voltage to the filament is employed, a potential gradient develops between the filament and an anode electrode (not shown), and the filament and a grid (not shown) due to a voltage drop of the filament. This induces differential in luminance of both ends of the filament.

Accordingly, in order to reduce influence of the potential gradient as shown in Fig. 10(a), a second prior art display device including a plurality of sets of two filaments 661, 662 (one set shown) has been proposed. As shown, polarities of the two filaments 661, 662 are provided to be different from each other as will be described later.

The filaments 661, 662 are supported by a first set of an anchor 642 and a support 652 and a second set of another anchor 641 and another support 651, respectively. To be more specific, one filament, e.g., 662 has both ends fixed to a first set, one end to the anchor 641 and the other to the support 651, and the other filament 661 has both ends fixed to a second set, one end to the anchor 642 and the other to the support 652. The anchors 641, 642 are respectively mounted on a glass substrate 61 via their corresponding metallic plates 621, 622, and the supports 651, 652 are respectively mounted on the glass substrate 61 via their corresponding metallic plates 631, 632. Under this

condition, a positive potential is applied to the metallic plates 621, 632 and a negative potential is applied to the metallic plates 622, 631.

There are shown in Fig. 11, a partial top view of a third prior art display device including linear spacers 851 (one shown), a damper 852 and filaments 86 (only one is designated by the reference numeral), and a cross sectional view taken along a line X3-X3 of Fig. 11(a), respectively.

As shown, one end of the filament 86 is connected to a cathode electrode 82, and similarly the other thereof (not shown) is connected to another cathode electrode (not shown). The filament 86 has a predetermined vertical position sustained by the spacer 851 disposed near one cathode electrode 82 and another spacer (not shown) disposed near the other cathode electrode 82. The spacer 851 made of a metal line has both ends fixedly attached to spacer supports 831, 841. The spacer supports 831, 841 are fixedly mounted on a glass substrate 81 via an insulating layer 84. The damper 852 made of a metal line is installed between the spacers to prevent the filament 86 from coming into contact with other components mounted at the glass substrate 81. Similar to the spacer 851, the damper 852 has both ends fixed to a pair of damper supports 832, 842. In this prior art, the supports 831, 832 and 841, 842 are respectively corresponding to the anchor 54 and the support 55 shown in Fig. 9 according to the first prior art.

[PROBLEM TO BE SOLVED BY THE INVENTION]

In the first display device of Fig. 9, the supporting member such as the anchor or the support is of a complicate shape due to the three-dimensional shapes, increasing factory expenses thereof and making a mounting process of the filament difficult. Additionally, the supporting members should have a predetermined strength, setting a limit on the miniaturization of the device. In other words, it is difficult to make the display device thin. Further, since the area for mounting the supporting member and the metallic plates is large, the space excepting for the display area, so-called dead space, is enlarged.

The second display device of Fig. 10 solves the potential gradient between the filament and the anode electrode and between the filament and the grid, but the mounting space for the supporting member and the metallic plates is about twice as much as that of the first prior art display device. That is, the spatial problem still remains.

Similar to the first display device of Fig. 9, the supporting member such as the anchor or the support of the third display device of Fig. 11 is also of a complicate shape due to three-dimensional shapes, increasing factory expenses thereof and making a mounting process of the spacer and the damper difficult. Further, the supporting member should have a predetermined strength that in turn sets a limit on the miniaturization of the device. On the other hand, it is

difficult to make the display device thin.

It is, therefore, an object of the present invention to provide a display device formed by ultrasonic-welding a cathode linear member, e.g., a cathode filament to cathode electrodes of a metallic layer/plate fixedly attached on a base, e.g., a glass substrate; cathode supporting auxiliary linear supports such as a cathode spacer, a cathode damper or the like on its corresponding fixing metallic layer/plate formed on the base; a grid linear member, e.g., a wire grid, on grid electrodes fixedly formed on the base; and, grid supporting auxiliary linear supports, e.g., a grid spacer, a grid damper or the like on their corresponding fixing metallic layer/plate fixedly attached on the base, respectively.

[SOLUTION PROVIDED BY THE INVENTION]

In accordance with a preferred embodiment of one aspect of the invention, there is provided an electron tube including: at least one metal layer formed on a base; at least one metal piece disposed on said at least one metal layer; at least one linear member interposed between said at least one metal layer and said at least one metal piece, wherein said at least one linear member is fixedly attached to said at least one metal layer by welding said at least one metal piece to said at least one metal layer.

In accordance with another preferred embodiment of the aspect of the invention, there is provided an electron tube

including: at least one cathode electrode formed on a base; at least one metal piece disposed on said at least one cathode electrode; at least one cathode linear member interposed between said at least one cathode electrode and said at least one metal piece, wherein said at least one cathode linear member is fixedly attached to said at least one cathode electrode by welding said at least one metal piece to said at least one cathode electrode.

In accordance with still another preferred embodiment of the aspect of the invention, there is provided an electron tube including: at least one grid electrode formed on a base; at least one metal piece disposed on said at least one grid electrode; at least one grid linear member interposed between said at least one grid electrode and said at least one metal piece, wherein said at least one grid linear member is fixedly attached to said at least one grid electrode by welding said at least one metal piece to said at least one grid electrode.

In accordance with still another preferred embodiment of the aspect of the invention, there is provided an electron tube including: at least one metal layer formed on a base; at least one metal piece disposed on said at least one metal layer; at least one cathode supporting auxiliary linear member or at least one grid supporting auxiliary linear member interposed between said at least one metal layer and said at least one metal piece, wherein said at least one cathode supporting auxiliary linear member or said at least one grid supporting auxiliary linear

member is fixedly attached to said at least one metal layer by welding said at least one metal piece to said at least one metal layer.

In accordance with still another preferred embodiment of the aspect of the invention, there is provided each of the above electron tubes, wherein the welding is achieved by using an ultrasonic bonding.

In accordance with still another preferred embodiment of the aspect of the invention, there is provided each of the above electron tubes, wherein said at least one metal piece is independently provided to said at least one linear member.

In accordance with still another preferred embodiment of the aspect of the invention, there is provided each of the above electron tubes, wherein said at least one linear member is divided into a plurality of sets and said at least one metal layer is at least one pair of metal layers, each of the sets being provided with one pair of said at least one pair of metal layers.

In accordance with a preferred embodiment of another aspect of the invention, there is provided a method for producing an electron tube including the steps of: interposing at least one linear member between at least one metal layer formed on a base and at least one metal piece disposed on said at least one metal layer; and fixing said at least one linear member to said at least one metal layer by ultrasonic-bonding said at least one metal piece to said at least one metal layer.

In accordance with another preferred embodiment of said another aspect of the invention, there is provided a method for producing an electron tube including the steps of: interposing at least one cathode linear member between at least one cathode electrode formed on a base and at least one metal piece disposed on said at least one cathode electrode; and fixing said at least one cathode linear member to said at least one cathode electrode by ultrasonic-bonding said at least one metal piece to said at least one cathode electrode.

In accordance with still another preferred embodiment of said another aspect of the invention, there is provided a method for producing an electron tube including the steps of: interposing at least one grid linear member between at least one grid electrode formed on a base and at least one metal piece disposed on said at least one grid electrode; and fixing said at least one grid linear member to said at least one grid electrode by ultrasonic-bonding said at least one metal piece to said at least one grid electrode.

In accordance with still another preferred embodiment of said another aspect of the invention, there is provided a method for producing an electron tube including the steps of: interposing at least one cathode supporting auxiliary linear member or at least one grid supporting auxiliary linear member between at least one metal layer formed on a base and at least one metal piece disposed on said at least one metal layer; and fixing said at least one cathode supporting auxiliary linear

member or said at least one grid supporting auxiliary linear member to said at least one metal layer by ultrasonic-bonding said at least one metal piece to said at least one metal layer.

[DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS]

There are shown in Fig. 1(a) and 1(b), a partial top view of a filament mounting part of a display device in accordance with a first preferred embodiment of the present invention, and a cross sectional view taken along a line Y1-Y1 of Fig. 1(a), respectively.

As shown, a reference numeral 11 represents a base or a substrate made of an insulator, e.g., a glass or the like; reference numerals 12, 13 cathode electrodes of metallic layer (or metallic film), made of e.g., Al and extracted to outside via cathode wirings (not shown) or cathode terminals (not shown); 14, 15 spacers made of an insulator, e.g., glass fiber; 16 cathode filaments (only one is designated by the reference numeral) made of, e.g., W or Re-W alloy; 161 a coil portion for exerting a predetermined tension force on the filament 16; 162 one end of the filament 16; and 17 welded pieces (only one is designated by the reference numeral) made of, e.g., Al wire. The glass substrate 11 between the spacers 14, 15 is provided with an anode electrode (not shown) having a fluorescent substrate (e.g., ZnO:Zn) applied thereon and wirings (not shown) extended to outside opposite to the filament 16 installed

thereat, for extracting the anode electrode to outside.

One end 162 of the filament 16 is coupled to one of the Al thin film, e.g., 12 to be interposed between the Al wire 17 and the Al thin film 12. The Al wire 17 is welded to the Al thin film 12 by using, e.g., an ultrasonic bonding. Similarly, the other end of the filament 16 is connected to another Al thin film 13. In this case, each of the Al wires 17 is cut to a plurality of metallic pieces by a suitable cutter.

The term "the cathode electrodes 12, 13" used here represent electrodes to which both end of the filaments 16 are connected respectively. Further, the term "cathode terminal" or "cathode wiring" refers to the terminal or the wiring whose one end is connected to the cathode electrode 12 or 13 and the other end thereof is extracted to outside, acting as a power feeding point.

The substrate 11 and the Al thin film 12 are respectively designed to have thickness of about 1.1 mm and about 1.2 μm. And, the Al wire 17, the filament 16 and the spacers 14, 15 are respectively designed to have a diameter of about 0.1 mm and more, preferably 0.5 mm, about 15 μm (0.64 MG) and about 1.0 mm. Further, the welding is carried out under the condition of the ultrasonic output of 15 W, the load of a wedge tool of 1100g and the bonding time of 250 m sec. In this embodiment, it is possible to obtain the binding strength of an approximately 20 N which is much stronger than 0.5 N of the line strength of the filament 16.

Although the above discussions refer to a situation where the welded wire and the cathode electrodes are made of Al, these members may be made of copper, gold, nickel, silver or the like. Further, the wire (metallic piece) and the cathode electrodes (the metallic films) are preferably made of similar metallic material, but may be made of different materials from each other.

In this embodiment, the welding wire (the metallic piece) welds one end of the filament to the cathode electrode and then is cut to form electrically independent pieces. However, a plurality of pieces may be used from the beginning, instead of the welding wire.

In this embodiment, the cathode electrodes are formed in the thin films but may be formed in the thick film.

In this embodiment, one outer end of the filament is disposed at one outer end of the welded piece, but may be disposed at inner position or outside position of the welded piece.

In this embodiment, the welding wire has a circular cross section, but may have a polygonal shape or a flat shape.

The filament can be welded by using a laser or a resistance heating welding. In this case, tungsten constituting the filament or carbonate coated on the filament is evaporated by the heat to be attached on the fluorescent substance of the anode, generating a poor luminescence, or the Al thin film gets damaged by the heat. But, it is found that, when the ultrasonic bonding is employed, it is possible to prevent the above-

mentioned problems. For this reason, the ultrasonic bonding is valuable and more particularly suitable for welding a linear member such as the filament to the metallic thin film.

In order to have the high resolution fluorescent display device, the cathode electrodes of the Al thin film should be formed of a narrow width, but this will decrease the binding strength between the Al thin film and its corresponding Al wire. Particularly, in the case of employing the laser or the resistance heating welding, the electric resistance becomes greater due to a chemical change in the bonding surfaces. On the other hand, in the case of ultrasonic bonding, it is found that these problems are prevented.

There are shown in Fig. 2(a) and 2(b), a partial top view of a filament mounting part of a display device in accordance with a second preferred embodiment of the present invention and its cross sectional view taken along a line Y2-Y2 of Fig. 2(a), respectively.

As shown, a reference numeral 21 represents a glass substrate as a base; reference numerals 221, 222, 231, 232 cathode electrodes formed on the glass substrate 21 and made of metal layers, e.g., Al thin film; 24, 25 spacers made of an insulator (e.g., glass fiber); 261, 262 a first and a second cathode filament; 2611, 2621 coil portions of the filaments 261, 262; 2612, 2622 one side ends of the respective filaments 261, 262; and 271, 272 a first and a second metallic piece made of, e.g., welding Al wire. The first and the second Al piece 271,

272 for welding their corresponding filaments 261, 262 on its corresponding cathode electrode pairs 221, 231 and 222, 232, respectively.

The side end 2612 of the filament 261 is installed on the aluminum thin film 221 by ultrasonic welding with the side end 2612 interposed between the aluminum thin film 221 and the aluminum wire 271; and the side end 2622 of the filament 262 is installed on the aluminum thin film 222 by ultrasonic welding with the side end 2622 interposed between the aluminum thin film 222 and the aluminum wire 272. Thereafter, the aluminum wire 272 is cut into aluminum pieces by a cutter or the like. In the same manner, the other side ends of the filaments 261 and 262 are installed on the aluminum thin films 231 and 232 by ultrasonic welding. The spacers 24 and 25 are prepared in common for the filaments 261 and 262.

In the second embodiment, it is considerable that a filament mounting part includes a first set of the first filament 261 and its corresponding AL thin films 221, 231, and a second set of the second filament 262 and its corresponding the AL thin films 222, 232. The first and the second filament 261, 262 are respectively installed at the base 21 by using their corresponding sets of AL thin films 221, 231 and 222, 232.

In such a structure, by applying the positive and the negative potentials to a first pair of Al thin films 221, 232 and a second pair of Al thin film 222, 232 respectively, the first and the second pair of Al thin films have an adverse

potential gradient to each other. For that reason, even if a driving system of applying DC voltage to the filaments is employed, approximately uniformed potentials are maintained between the filaments and the anode electrode and the filaments and the grid regardless of their locations. Accordingly, the display device has an approximately uniformed luminance at the front thereof.

In such a filament mounting part, the current flowing in each of the Al thin films becomes a half of that of the first embodiment. This allows the width of the Al thin films to be reduced into a half thereof (Further, a gap between the Al thin films is approximately several tens of μm and therefore is negligible). Consequently, the area for forming the Al thin films is substantially identical to that of the first embodiment. Additionally, even if the widths of the Al thin films are narrow, the ultrasonic bonding is employed, thereby eliminating damages due to the heat using the laser or the resistance heating welding at a heating time, e.g., breaking the Al thin films.

Moreover, since only two spacers 24, 25 are required for maintaining the vertical position of the filaments 261, 262, there is no reason for increasing the number of the spacer compared with the first embodiment.

There are shown in Fig. 3(a), 3(b) and 3(c) a view for setting forth how to weld the Al piece 17 of Fig. 1(a), a cross sectional view taken along a line Y3-Y3 of Fig. 3(a), and a cross sectional view taken along a line Y4-Y4 of Fig. 3(a),

respectively.

As shown, a reference numeral 18 represents a wedge tool having, e.g., a V-shaped groove 181 in a longitudinal direction of the filament.

After one end 162 of the filament 16 and the Al wire 17 are successively overlapped on the Al thin film 12 formed on the glass substrate 11, the groove 181 of the wedge tool 18 is aligned with the longitudinal direction of the Al wire 17. Under this condition, when the wedge tool 18 is driven by the ultrasonic waves, the Al wire 17 is welded to the Al thin film 12 to envelope the end 162 of the filament 16. The Al wire is cut by a cutter (not shown) after the welding.

The wedge tool may be of various shapes and the known ultrasonic bonding device may be employed.

There are shown in Fig. 4(a), 4(b) and 4(c), a partial top view of a filament mounting part of a display device in accordance with a third preferred embodiment of the present invention, a cross sectional view taken along a line Y5-Y5 of Fig. 4(a), and a cross sectional view taken along a line Y6-Y6 of Fig. 4(a), respectively.

The third embodiment is similar to the first embodiment, excepting for the length of an Al wire 47.

Referring to Fig. 4, each one end 462 (one shown) of filaments 46 is interposed between the Al thin film 42 and the Al wire 47 and then is welded to the Al thin film 42 by, e.g., the wedge tool. Similarly, the other end (not shown) of each of

the filaments 46 is welded to the Al thin film 43.

In this embodiment, the ends 462 of filaments 46 are capable of being welded to the Al thin film 42 by using its corresponding one Al wire 47. That is, just like the Al wires of Figs. 1 and 2, when the filaments 46 are welded to the film 42, it is unnecessary to cut the Al wire into a plurality of pieces as illustrated in the first embodiment. Accordingly, the welding process is simple. The Al wire 47 is also usable as a cathode electrode, and therefore, even when the Al thin films 42, 43 get damaged during the welding process, there will be no problems in feeding power to the filaments.

Additionally, when the current capacity of the Al thin films 42, 43 is insufficient, it is possible for the Al wire 47 to compensate for the insufficient amount thereof. Consequently, the widths of the Al thin films 42, 43 can be reduced by as much as the area corresponding to the current amount compensated by the Al wire 47.

On the other hand, since, when the wedge tool having a relatively wide width is used for welding the Al wire 47, the ends 462 of the filaments 46 are simultaneously welded to the Al thin film 42, the installation of the filaments is simple and therefore it is possible to shorten the welding time.

In the present invention, in order to connect the filaments to the thin film cathode electrodes, the anode wirings, and the cathode electrodes (whether it performs double duty as the cathode wirings or the separate cathode wirings are formed)

and the anode electrode are firstly formed on the glass substrate. Next, the fluorescent substrate is applied on the anode electrode and then the insulating spacers are installed at the glass substrate. Subsequently, the ends of the filaments are connected to the cathode electrodes and then are covered by the Al wires. Thereafter, the welded members are welded to the thin film cathode electrodes by using the wedge tool performing the ultrasonic bonding. That is, the filaments are welded to the thin film cathode electrodes under the condition of being fixedly positioned between the welded members and the thin film cathode electrodes. On the other hand, plane grids may be provided around the anode electrodes.

The welded metallic wires as a metallic piece may be made of, e.g., copper, gold, nickel or silver and have various shapes, e.g., a circular, polygonal shape in a section or a flat shape. Further, instead of employing the metallic wires as the welded members, it is possible to use a plurality of separate metallic pieces.

There are shown in Fig. 5(a), 5(b) and 5(c), a partial top view of a damper mounting part included in a display device in accordance with a fourth preferred embodiment of the present invention and a cross sectional view taken along a line Y1-Y1 of Fig. 5(a), respectively. Fig. 5(c) shows a cross sectional view of a modification of Fig. 5(b). The fourth embodiment is similar to the first embodiment excepting for further including the linear damper as a cathode supporting auxiliary linear

member mounting between the spacer 14 and 15.

Referring to Fig. 5, the damper mounting part in accordance with the fourth embodiment includes a linear metallic damper 180 as a cathode supporting auxiliary member, a pair of Al thin films 19 on the glass substrate 11 and a pair of Al wires 20 on the Al thin films 19. The damper 180 is made of, e.g., W, Mo or stainless, and both ends thereof are respectively interposed between two pairs of the Al thin films 19 and the Al wires 20 and then are secured to its corresponding Al thin film 19 by welding its corresponding Al wire 20. In this case, the Al thin films 19 and the Al wires 20 for the damper 180 are respectively corresponded to the Al thin film 12 and the Al wire 17 for the filament 16. The damper 180 maintains its vertical position by using spacers 142. In this case, the damper spacer 142 is made of an insulator, e.g., glass fiber, and is corresponded to the filament spacer 141.

The damper spacer 142 has a smaller diameter by as much as the diameter of the damper 180 than that of the filament spacer 141, but may have an identical diameter to that of the filament spacer 141. On the other hand, since, when the filament 16 is always in contact with the damper, the radiant heat of the filament 16 increases at the contact part. As a result, it is preferable that the damper spacer 142 may have a smaller diameter than that of the filament spacer 141. To be more specific, preferably, the damper spacer 142 has a smaller diameter than that of the filament spacer 141 in such a way that,

only when the filament 16 is vibrating, it will contact with the damper 180.

The damper 180 may be made of an identical material with the filament spacer 141. In this case, the damper 180 is capable of being installed at the glass substrate 11 as the filament spacer 141.

Fig. 5(c) presents a modification of Fig. 5(b) in which a filament spacer 143 as a cathode supporting auxiliary linear member similar to the damper 180 instead of the spacer 141 is included. In this case, similarly to the installation of the damper 180, the ultrasonic bonding is usable in the installation of the filament spacer 143.

Such a damper 180 and/or a filament spacer 143 can be employed in the second and the third embodiment.

The damper 180 and the filament spacer 143 are described as the cathode supporting auxiliary linear member (the filament spacer, the filament damper), but can be used for a grid supporting auxiliary linear member for a grid (see Fig. 6) (a wire grid spacer, a wire grid damper) as will be described later.

There are shown in Fig. 6(a) and 6(b), a partial top view of a filament mounting part included in a display device in accordance with a fifth preferred embodiment of the present invention and a cross sectional view taken along a line Y7-Y7 of Fig. 6(a), respectively. This embodiment includes a wire grid as a grid supporting auxiliary linear member.

As shown, a reference numeral 311 represents a glass anode

substrate as a base, 312 a back glass substrate, 313 side glass plates (only one is designated by the reference numeral). Furthermore, As shown, a reference numeral 33 presents wire grids (only one is designated by the reference numeral) as a grid linear member, 341, 342 wire grid spacers having rod shape, 36 filaments (only one is designated by the reference numeral) and 37 an anode having an anode electrode and a fluorescent substance formed on the anode electrode. The wire grid 33 has a predetermined vertical position maintained by using the spacers 341, 342 made of insulator, e.g., glass. And, both ends of the wire grid 33 are respectively welded to grid electrodes 321, 322 formed on the glass substrate 311 by using Al wire as metallic pieces 351, 352. In this case, the ultrasonic bonding is employed. The grid electrodes 321, 322 are made of Al thin film and perform a double duty as a grid terminal or a grid wire for extracting the grid electrode to the outside.

The wire grid spacers 341, 342 may be made of a metal line. For instance, the wire grid spacers 341, 342 may be the metal line as the filament spacer 143 (a linear spacer) as shown in Fig. 5(c) instead of the rod shape insulating material, for supporting the grid.

On the other hand, this embodiment may further include metal lines as a grid supporting auxiliary linear member as the damper 180 shown in Fig. 5(a).

There is shown in Fig. 7(a) and 7(b), an expanded cross sectional view of a part of Fig. 6(b), and a cross sectional

view of a prior art. There is shown in Fig. 7(a) for illustrating the connection of the Al thin film 321 and the wire grid 33, while there is shown in 7(b), the corresponding part of the prior art.

Hereinafter, Fig. 7(b) will be described. First, under the condition of applying a predetermined tension force to the wire grid 33 mounted on jigs of circumference shape, the wire grid 33 is mounted on the glass anode substrate 311, and the position against the anode 37 is adjusted. Then, as shown in Fig. 7(b), the wire grid 33 is interposed between the glass anode substrate 311 and the side glass plates 313 applied with the fritted glass 314, thereafter being adhered. After that, each of the jigs is heated in a heating furnace, thereby being sealed and exhaust, and thereafter, the wire grid 33 is cut with reserving a grid terminal 331. The wire grid 33 has a predetermined vertical position sustained by the spacer 340, having the rod shape and being made of an insulating material such as glass.

In the prior art embodiment of Fig. 7(b), the initial position of the wire grid 33 is deviated in sealing process, setting a limit on the high resolution. Further, since the wire grid is extracted from a casing to the outside, the wire grid should be made of the material having a thermal expansion coefficient similar to that of glass. This sets a limit on the material of the wire grid, e.g., 426 alloy (Ni 42%, Cr 6%, the remaining Fe). Additionally, the connection of the wire grid

and the printed circuit board such as a drive circuit is achieved by soldering leads to the ends of the wire grid and the terminal of the printed circuit board.

The fifth embodiment of Fig. 7(a) solves the problems of this prior art. To be more specific, the wire grid 33 made of, e.g. W, Mo or stainless, maintains its vertical position by using the spacers 341. Under this condition, one end of the wire grid 33 is secured to the grid electrodes 321 by using the ultrasonic bonding. As a result, it is possible to preserve the initial position of the wire grid 33 even when the attachment or the sealing thereof is carried out.

Further, since it is not required for the jig or for loading the jig into the heating furnace, the mounting process of the wire grid 33 is simple and it is possible to effectively use the heating furnace.

Since the ends of the wire grid 33 are located within the vacuum casing of the fluorescent display device, it is possible to select the material of the wire grid regardless of the thermal expansion coefficient of glass. Moreover, since the grid electrode 321 is extracted to the outside, it is easy to connect the wire grid 33 to the printed circuit board by using thermo compression bonding.

The term "grid electrode" used here represents the electrode at which the wire grid is installed and "grid wiring" used here refers to the terminal or the wiring which is connected to the grid electrode and is extracted to the outside

of the display device to function as a power feeding point.

Fig. 8 shows a cross sectional view of a part of a spacer of Fig. 6, and an inverted perspective view and a cross sectional view of another spacer. Referring to Fig. 8(a) showing a partial cross sectional view taken along a line Y8-Y8 of Fig. 7(a), the spacer 341 is fixedly attached to the grid electrode 321 by using, e.g., the fritted glass.

There are shown in Figs. 8(b) and 8(c), an example of employing a convexoconcave spacer 74 and a partial cross sectional view taken along a line Y9-Y9 of Fig. 8(b), respectively.

As shown, the spacer 74 has at its periphery a plurality of recesses 741 (only one is designated by the reference numeral) for accommodating their corresponding wire grids. The recess 741 serves to position the wire grid 33.

Although the above discussions refer to the fluorescent display device, identical results can be obtained in an electron tube, for instance, a display tube including a CRT, a discharge tube including a hot cathode discharge lamp and a vacuum tube incorporating therein linear members such as the filaments or the wire grids and the auxiliary supporting members such as the linear spacers or the linear dampers.

[EFFECT OF THE INVENTION]

Since the present invention can install a linear member,

such as a linear filament or a wire grid, and a supporting auxiliary member, such as a spacer or a damper, to a metal layer, such as a thin film cathode electrode or a thin film grid electrode, without employing the supporting member, such as the anchor, the support, the spacer or the like, that has a complicate shape due to the three-dimensional shapes. Accordingly, the present invention reduces the manufacturing cost, and simplifies the process of installing the linear member or the supporting auxiliary member.

Further, the present invention can make the display device thin, thereby reducing the dead space, i.e., the space excepting for the display area.

Since the filament is ultrasonic-welded to the cathode electrode in the present invention, tungsten constituting the filament or carbonate coated on the filament is not evaporated during the fixing process. Therefore, it is not necessary to remove carbonate from the filament at the welding position in advance. For this reason, the contamination of the fluorescent substrate, which occurs during the filament fixing process, can be reduced. Furthermore, the thin film cathode electrode is not damaged by the heat generated during the filament fixing process.

In the present invention, with respect to a driving system for applying DC voltage to the filament, even though filaments are divided into a plurality of sets to diminish a potential gradient along the filament, since the thin film

cathode electrodes can be divided into a plurality of sets, the space for the cathode electrodes is hardly changed. Since the metal layer and the metal piece (metal wire), which interpose a linear member or a supporting auxiliary linear member, are ultrasonic-welded in the present invention, the electric resistance, due to a chemical change in the bonding surfaces of the metal layer (such as a cathode electrode) and the metal piece (metal wire), does not become greater.

In the present invention, it is possible to employ a common continuous metal wire for a plurality of filaments and to ultrasonic-weld the metal wire to the thin film cathode electrode without need to be cut for every filament. Accordingly, the welding process becomes simple, and the welding time can be shortened. Further, since the metal wire can be used as a portion of the cathode electrode, even if the cathode electrode is damaged or the current capacity is insufficient, it is possible to compensate the functionality of the cathode electrode by the metal wire.

In the present invention, a common continuous metal wire for ultrasonic welding is used for a plurality of filaments, and a wedge tool having a wide width is used. Therefore, the metal wire can be ultrasonic-welded to a cathode electrode for every filament at a time. Accordingly, the welding process becomes simple, and the welding time can be shortened.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 illustrates a top view and a cross sectional view of a filament mounting part of a display device in accordance with a first preferred embodiment of the present invention;

Fig. 2 depicts a top view and a cross sectional view of a filament mounting part of a display device in accordance with a second preferred embodiment of the present invention;

Fig. 3 presents expanded views of the filament mounting part for setting forth how to weld the Al wire of Fig. 1;

Fig. 4 represents a top view and cross sectional views of a filament mounting part of a display device in accordance with a third preferred embodiment of the present invention;

Fig. 5 describes views in case a damper is included in a display device of Fig. 1;

Fig. 6 sets forth a top view and a cross sectional view of a wire grid mounting part of a display device in accordance with a fourth preferred embodiment of the present invention;

Fig. 7 depicts an expanded cross sectional view of a part of Fig. 6 and a cross sectional view of the corresponding part of a prior art;

Fig. 8 shows a expanded cross sectional view of a part of a spacer of Fig. 6, and a inverted perspective view and a cross sectional view of another spacer;

Fig. 9 is a top view and a cross sectional view of a filament mounting part of a prior art display device;

Fig. 10 illustrates a top view and a cross sectional view

of a filament mounting part of a prior art display device in case filaments are divided into two sets; and

Fig. 11 presents a top view and a cross sectional view of spacers mounting part for filaments and a damper mounting part of a prior art display device.

Explanation about reference numbers

11, 21, 311, 312, 41: glass substrates

12, 13, 221, 222, 231, 232, 42, 43: Al thin films of cathode electrodes

14, 141, 142, 143, 15, 24, 25, 341, 342, 44, 45, 74: spacers

16, 261, 262, 46: filaments

17, 20, 271, 272, 351, 352, 47: Al wires

18: a wedge tool for ultrasonic welding

180: damper

19: Al thin film for fixing damper

314: fritted glass

321, 322: thin film grid electrodes

33: wire grid

37: anode

[ABSTRACT]

[PROBLEM TO BE SOLVED]

To install linear members, such as a cathode filament or a wire grid, and supporting auxiliary linear members, such as a linear spacer or a linear damper, on a metal layer such as a thin film cathode electrode by welding without using anchors and supports or the member equivalent to the anchors and supports, in an electronic tube such as a fluorescent display tube.

[SOLUTION]

The filament 16 is installed on an aluminum thin film 12 for cathode electrode formed on a glass substrate 11. With the end part 162 of the filament 16 interposed between the aluminum thin film 12 and an aluminum wire 17, the aluminum wire 17 is connected to the aluminum thin film 12 by ultrasonic welding. Since the aluminum thin film 12 is not affected by heat unlike the case of heat welding, the thin film is not damaged nor deteriorated. In addition, the filament and a coat material applied thereon are not evaporated by heat during welding, thereby preventing a contamination of a fluorescent body.

[SELECTED DRAWING] Fig. 1